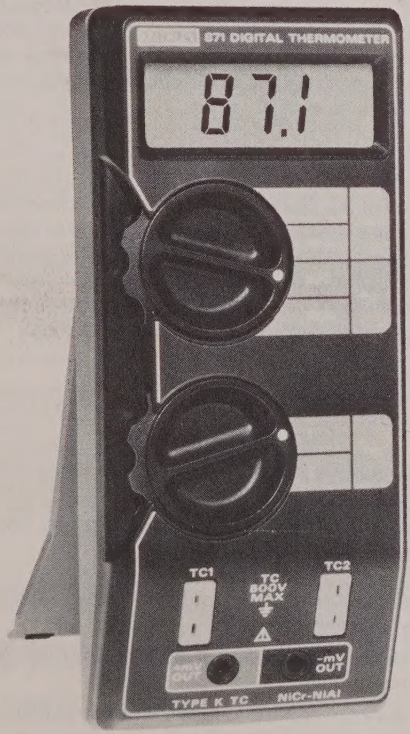
KEITHLEY

Model 871
Digital Thermometer
Instruction Manual

Please return to librarian:
Org. B-8729 MS 47 - 24
Manual # 1A S/N 3X94xxx



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SERVICE POLICY

For service on your Model 871 Digital Thermometer, contact your local Keithley representative who will be able to give you immediate assistance in most cases. Complete repair and calibration facilities are maintained in the United States, West Germany, Great Britain, France, the Netherlands, Switzerland, and Austria. Information concerning the application, operation or service of your instrument may be directed to the applications engineer at any of the above locations. (Addresses are located on the back cover.)

WARRANTY

We warrant each of our products to be free from defects in material and workmanship. Our obligation under this warranty is to repair or replace, at our option, any instrument or part thereof which, within a year from date of shipment, proves defective upon examination. We will pay local domestic surface freight costs. (NOTE: This warranty does not cover battery replacement or damage due to battery leakage.)

SAFETY SYMBOLS AND TERMS

The symbol on the instrument denotes that the user should refer to the operating instructions.

The symbol on the instrument denotes that up to 500V may be present on the terminal(s).

The **WARNING** used in this manual explains dangers that could result in personal injury or death.

The **CAUTION** used in this manual explains hazards that could damage the instrument.

871 SPECIFICATIONS

TEMPERATURE SENSOR: Type K (NiCr-NiAl) thermocouple.

THERMOCOUPLE INPUTS: Two, switch selected.

RANGES

Ranges	Temperature Span	Resolution
200°F	−40.0 to 199.9°F	0.1°F
2000°F	−40 to 1999°F	1°F
200°C	−40.0 to 199.9°C	0.1°C
1370°C	−40 to 1370°C	1°C

ACCURACY: ±0.25% of reading ±1°C(0.25% ±1.8°F) for one year, 18° to 28°C ambient. Includes NBS conformity, cold junction compensation and repeatability errors. Excludes thermocouple errors, however, thermocouple errors around 0°C may be compensated for by an internal zero adjustment. Extended accuracy from −40°C to −55°C: +2°/−0°C.

REPEATABILITY: ±0.2°C typical for 1 hour at constant ambient temperature.

TEMPERATURE COEFFICIENT: 18° to 28°C; Included in accuracy specification. From 0° to 18° and 28° to 50°C; less than ±(0.025% of reading +0.1°C)/°C.

INPUT CURRENT: 25nA typical; 50nA maximum.

MAXIMUM ALLOWABLE TC INPUT OVERLOAD: 150V continuous, 300V momentary (10 seconds).

NORMAL MODE REJECTION RATIO: Greater than 45dB at 50 & 60Hz.

COMMON MODE REJECTION RATIO: Greater than 120dB at DC, 50 & 60Hz.

GENERAL

DISPLAY: 3½-digit LCD, 0.6" height. Polarity and decimal point indication.

CONVERSION PERIOD: 400ms (2.5 readings/sec).

OVERRANGE & OPEN-THERMOCOUPLE INDICATION: 3 least significant digits blanked.

MAXIMUM COMMON MODE VOLTAGE[1]: 500V peak to earth.

TC1 TO TC2 ISOLATION[1]: 500V peak.

mV OUTPUT: Non-linearized, cold-junction compensated thermocouple output. (Not isolated from selected TC input.)

mV OUTPUT ACCURACY (18°-28°C): ±40μV (°C ranges); ±80μV (°F ranges).
0°C = 0.0mV. Output resistance: 17kΩ.

mV OUTPUT TEMPERATURE COEFFICIENT (0°-18°C & 28°-50°C): Less than (0.1 × accuracy specification)/°C.

mV OUTPUT PROTECTION: 35V DC (42V peak) maximum; mV+ to mV- and selected TC input to mV+ or mV−.

ENVIRONMENTAL LIMITS FOR OPERATING: 0° to 50°C, less than 80% relative humidity up to 35°C, linearly derate 3% R.H./°C 35° to 50°C. If the instrument has been stored above 18°C it may typically be operated at −10°C for 15 minutes.

ENVIRONMENTAL LIMITS FOR STORAGE: -35°C to 60°C, less than 90% relative humidity up to 35°C; linearly derate 3% R.H./°C 35° to 60°C.

COLD-JUNCTION COMPENSATION: Semiconductor temperature sensor.

THERMOCOUPLE LINEARIZATION: Multislope A/D with 11 piece-wise-linear segments between -40°C and 1370°C.

INPUT CONNECTIONS: Two, miniature TC connectors.

mV OUTPUT CONNECTION: Dual banana jacks.

POWER: 9V alkaline or carbon-zinc (NEDA 1604) battery.

BATTERY LIFE (CONTINUOUS): 100 hours typical with alkaline battery; 50 hours typical with carbon-zinc battery.

BATTERY INDICATOR: Display indicates "BAT" when less than 10% of life remains.

DIMENSIONS, WEIGHT: 178mm long × 78mm wide × 42mm thick (7.0" × 3.1" × 1.6"). Net weight 300gm (10.6oz).

ACCESSORIES SUPPLIED: Battery, manual, Model 8712 Thermocouple Sensor.

[1]WARNING: A shock hazard exists when probes or sensors are exposed to voltage levels greater than 30V rms or 42.4V peak.

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GENERAL INFORMATION

The Model 871 is supplied ready for use with a battery and a thermocouple probe (Model 8712). The thermometer is designed to work with any type-K thermocouple probe or sensor that is terminated with a miniature thermocouple plug. Descriptions of other available probes and accessories can be found below.

MANUAL ADDENDA

Any changes to the instrument which occur after the printing of this manual will be explained in an addendum included with the instrument.

OPTIONAL ACCESSORIES

The following optional accessories can be used with the Model 871, and are obtainable through a Keithley representative.

Model 1304 Soft Carrying Case and Stand for the Model 871.

Model 1306 Heavy Duty Carrying Case is a rugged carrying case that is large enough to accommodate the Model 871 plus various other articles such as a spare battery, manual, the Model 8712, etc.

Model 8700 Carrying Case With Belt Clip & Holster for the Model 8714 Probe.

Model 8711A Thermocouple Kit includes Model 8712 Thermocouple Sensor, 6m (20') of AWG #24 type K duplex TC wire, miniature TC plug/jack, standard TC plug/jack.

Probes and Sensors

Model 8712 Thermocouple Sensor consists of a three foot TC wire sensor that has a beaded thermocouple junction.

Model 8713 Immersion Probe for liquid and general purpose applications up to 900°C.

Model 8714A Penetration Probe with coiled cord for measurements of soft and semi-frozen solids.

Model 8715 Surface Probe for measurement of flat surfaces of solids.

Model 8716 Air/Gas Probe-Exposed junction within protective shroud responds to ambient temperature while shielded from incident radiation.

PREPARATION FOR USE

Carefully unpack the Model 871 from its shipping carton and inspect for any obvious signs of physical damage. Report any damage to the shipping agent at once. The following items are included with every Model 871 shipment.

1. Model 871 Digital Thermometer
2. Model 871 Instruction Manual
3. Model 8712 Thermocouple Sensor
4. 9V Battery (NEDA 1604)
5. Optional accessories as requested.

BATTERY INSTALLATION/REPLACEMENT

A 9V battery is supplied with the instrument but not installed. Read over the following installation instructions before attempting to install or remove the battery.

WARNING

Turn the Model 871 off and disconnect the input probes before replacing the battery. Put the cover back into place on the battery compartment before resuming use of the instrument.

Remove the cover from the battery compartment by sliding it off in the direction of the arrow located on the battery cover. The battery connector snaps on and off the terminals of the battery. Improper installation of the battery will cause the connecting wires to be severed by excess strain. Proper installation requires that the battery be positioned in such a manner (see Figure 1) that the leads protruding from the boot of the battery connector face toward the outside of the battery compartment. If the instrument is going to be stored for a long period of time or in a high temperature environment, remove the battery to prevent leakage damage.

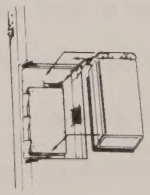
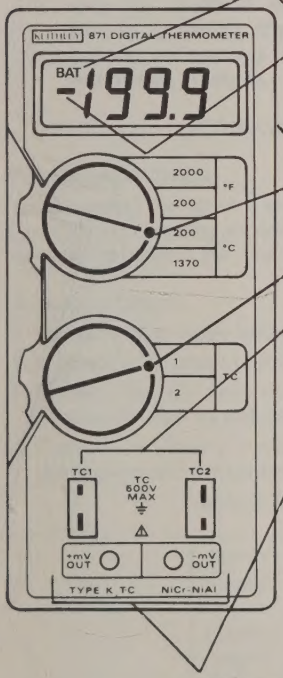


Figure 1. Battery Installation

OPERATION

The Model 871 Digital Thermometer requires the use of K-type TC probes/sensors, such as the Model 8712 Thermocouple Sensor which is a supplied accessory.



Low Battery Indicator

Minus sign displayed; plus sign implied.

1 Overrange condition or open thermocouple.

1. **SET POWER ON.**
2. **SELECT SCALE AND RANGE.**
   Fahrenheit: 200°F or 2000°F
   Celsius: 200°C or 1370°C
3. **SELECT THERMOCOUPLE-TC1 or TC2.**
4. **INPUT CONNECTORS TC1 and TC2.**
   The Model 871 will accommodate one or two probes/sensors that are terminated with standard miniature type K TC plugs
5. **ANALOG OUTPUT JACKS.**
   +mV OUT and −mV OUT-Use a recorder to monitor temperatures or a sensitive DMM to make high resolution readings. Use the NBS Thermocouple Calibration Tables for converting voltage readings into temperature readings.

Figure 2. Control Layout

WARNING

A shock hazard exists on the Model 871 input terminals when probes or sensors are exposed to voltage levels greater than 30V rms or 42.4V peak (A.N.S.I.).

CAUTION

To avoid instrument damage do not apply more than 150V across the input terminals of the Model 871.

NOTE

Analog output source resistance is 17kΩ. External load resistance of $\geq$10MΩ keeps loading error $\leq$0.17% of reading.

SERVICING INFORMATION

This section contains servicing information for the Model 871.

WARNING

The information presented in this section is intended only for qualified personnel. Turn off the power before replacing the battery. Replace all covers before connecting the instrument to potentially hazardous voltages.

VERIFICATION PROCEDURE

Functionality Check:

While holding the tip of a clean TC probe between your thumb and index finger, a reading ascending to between 25° and 40°C should be obtained to confirm the functionality of the Model 871.

Accuracy Check:

1. Prepare a pure-water ice bath. (See Calibration Setup Procedure.)
2. Connect a TC probe to input channel 1 (TC1) of the Model 871.
3. Immerse the TC probe into the pure-water ice bath and allow 10 minutes for thermal stabilization.
4. Turn on the Model 871 and use the following table to verify that the readings on each range are within specifications.

Table 1. Verification Summary

Range	Allowable Reading
2000°F	32° ± 2°
200°F	32.0° ± 1.8°
1370°C	0° ± 1°
200°C	0.0° ± 1.0°

Environmental Conditions

The Model 871 should be at an ambient temperature of 23° ± 1°C; relative humidity less than 80%.

CALIBRATION

Equipment Needed:

1. DC Voltage Calibrator with ±0.01% of setting ±20μV accuracy

(Fluke 341A or equivalent).

2. 100:1 divider—1.98kΩ and 20Ω resistors, .02% ratio accuracy or better, Wirewound.
3. Pure-water ice bath—Dewer Flask or 1 quart thermos.
4. K-type TC wire terminated with a standard miniature type K TC plug (see Figure 3) and a copper wire pair.

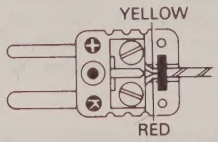


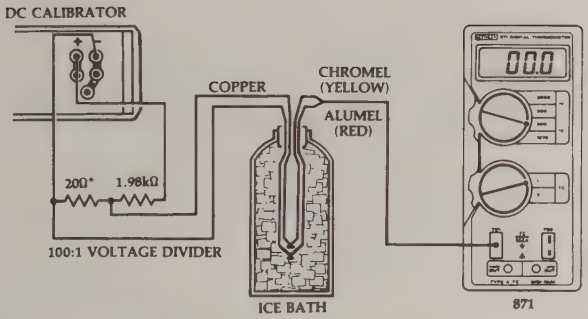
Figure 3. Type K TC Plug

Calibration Set-Up:

1. Turn on voltage calibrator.
2. Connect the TC plug (Figure 3) to the TC1 input of the Model 871.
3. Splice copper wires to the TC wires. Crimp lugs can be used for making the splice.
4. Connect the other ends of the copper wires to the 100:1 divider as shown in Figure 4. Connect the copper/iron wire to the positive side.
5. Connect the 100:1 divider to the DC voltage calibrator as shown.
6. Prepare the pure water ice bath as follows:
   a. Drill a hole in the cap of a Dewar flask or thermos to accomodate the thermocouples.
   b. Firmly pack the flask with pea-size ice cubes made from distilled water, and then fill the flask with distilled water.
   c. Replace the melted ice with more ice while removing the excess water.
   d. Place the cap on the flask. Immerse the thermocouples into the flask and allow 20 minutes for temperature stabilization.

Calibration Procedure

1. Remove the battery cover and trimmer compartment cover from the Model 871. (See Figure 5.)
2. Turn the Model 871 on and perform the calibration adjustments listed in Table 2.



*The 200 resistor must be held at a uniform temperature during calibration.

Figure 4. Setup Procedure

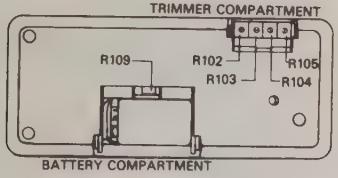


Figure 5. Model 871 Rear Panel

Table 2. Calibration Adjustments

Step	Adjustment	871 Range	Calibrator Setting (V)	Trimmer Adjust	Desired Reading
1	Input Offset Null	200°C	0.0000	R109	00.0°C
2	+ Gain (× 1)	1370°C	5.3093	R104	1320°C
3	+ Gain (× 10)	200°C	0.6939	R105	170.0°C
4	− Gain	200°C	−.1527	R103	-40.0°C
5	°F Offset	200°F	0.0000	R102	32.0°F

PROBE MATCHING

To improve the accuracy of the Model 871 while using a particular probe, the calibration of the Model 871 can be adjusted so that probe errors in the region of zero (0°C) are compensated. Place the probe in an ice bath and allow the reading to stabilize. Then reset the zero adjustment (R109) to a 0.0°C reading.

DISASSEMBLY INSTRUCTIONS

Place the unit face down on a bench or other similar surface and remove the battery compartment cover. Remove and disconnect the battery. Remove the two #4-40 × 7/8 retaining screws (see Figure 6).

Grasp the bottom cover at the input jack end and with a lifting and forward pushing motion, carefully remove the bottom cover. While removing the cover, feed the battery connector through the access opening in the bottom of the battery compartment.

The component side of the PC board is now exposed and the battery can be reconnected for troubleshooting. To read the display, some light downward pressure at the top end of the circuit board may be required in order to make contact through the conductive elastomer strip, between the circuit board and the LCD.

The PC board and LCD assembly are not secured once the case retaining screws are removed. Be careful not to allow the PC board and LCD assembly to fall out or shift out of position.

To remove the PC board from the top cover, grasp the TC switch assembly and lift the board from the cover. The two switch knobs will remain in the case.

The LCD assembly will remain in the top cover when the PC board is removed. Again, be careful not to allow the LCD assembly to fall out accidentally.

The LCD assembly, along with the strip connector, lifts out of the case.

To reassemble the Model 871, reverse the above procedure.

NOTE

Proper alignment of the strip connector is necessary when reinstalling the LCD assembly. If the strip connector has a conductor side, make sure that side is positioned against the plastic support of the LCD assembly.

WARNING

Be sure to replace the on-off switch cover. Common-mode voltage will be present on the switch, creating a possible hazard if the cover is not replaced.

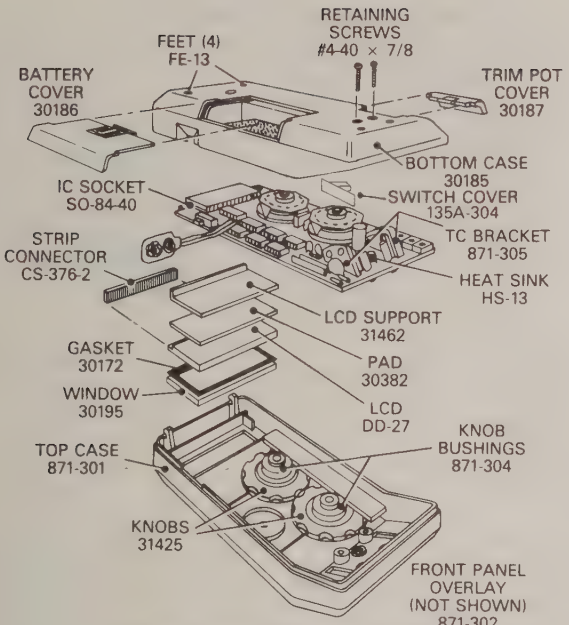


Figure 6. Model 871 Exploded View

TROUBLESHOOTING GUIDE

The following troubleshooting information is intended to be used by qualified electronic maintenance personnel who are familiar with the proper use of standard electronic test equipment.

To gain access to the PC board, refer to the first three paragraphs of the disassembly instructions. Utilize the parts list, schematic and component layout for identifying parts and check point locations. The following checks should be made with the Model 871 set to the 200°C Range.

DC Voltage Checks

1. Battery: $V_{BAT} > 7V$
2. Power Supplies:
   V+ to ↓ (Analog Common) = $+2.8 \pm 0.4V$
   V+ to ▽ ↓ (Digital Common) = $+5 \pm 1V$

3. Reference Diode: CR101 to ⏚ $= -1.23 \pm 0.03$V
4. Negative Reference Divider: (Reference to ⏚)

R119

Pin	mV*	Pin	mV*	Pin	mV*
2	−210	5	−204	8	−195
3	−209	6	−199	9	−186
4	−204	7	−198	10	−173

*The setting of R104 and the tolerances of the resistors within the network (R119) can affect these levels by ±5%.

5. Deintegrate Comparators:
   U103, Pin 3 to ⏚ $= 150 \pm 25$mV
   U103B, Pin 6 to ⏚ $= -150 \pm 25$mV
6. Cold Junction Voltage:
   (Ambient Temperature 25° ±3°C)
   -COM to ⏚ $= 1.0 \pm 0.6$mV

Waveform Checks: (Referenced to ⏚)

Clock	U111, Pin 3	360kHz, 5V pp	Square Wave
A/D Clock	U112, Pin 5	40kHz, 5V pp	Rectangular Wave
Ref. Clock 1	U102, Pin 9	60kHz, 5V pp	Rectangular Wave
Ref. Clock 2	U102, Pin 14	6kHz, 5V pp	Rectangular Wave
Backplane	U101, Pin 20	50Hz, 5V pp	Rectangular Wave

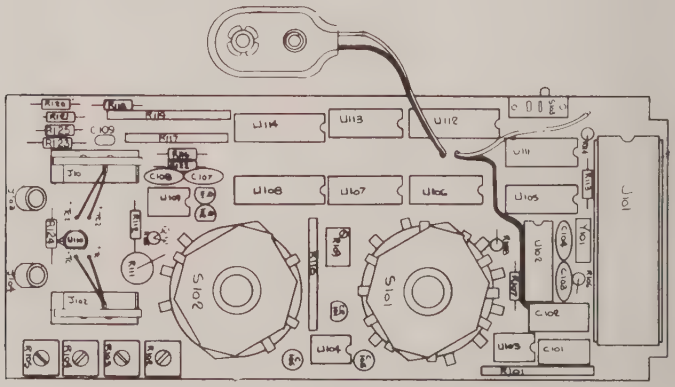
Parts List

Circuit Desig.	Description	Schematic Location	Keithley Part No.
BT101	Battery, 9V, NEDA 1604	H4	BA-14
C101	Cap, .22μF, 100V, Polyester	G3	C-305-.22
C102	Cap, .1μF, 100V, Polypropylene	G3	C-306-.1
C103	Cap, 470pF, 1000V, Ceramic Disc	E2	C-64-470p
C104	Cap, 220pF, 1000V, Ceramic Disc	D2	C-64-220p
C105	Cap, 10μF, 16V, Aluminum Electrolytic	H4	C-321-10
C106	Cap, 10μF, 16V, Aluminum Electrolytic	H5	C-321-10
C107	Cap, 33pF, 1000V, Ceramic Disc	C2	C-64-33p
C108	Cap, 47pF, 1000V, Ceramic Disc	B2	C-64-47p
C109	Cap, .1μF, 16V, Ceramic Disc	C3	C-238-.1
CR101	Diode, Low Voltage Reference	D6	DZ-62
DS101	Liquid Crystal Display 3 1/2 digit	F5	DD-27
J101	Connector, TC, Female	A1	CS-438
J102	Connector, TC, Female	A2	CS-438
J104	Jack, Female	C3	30300-3
J105	Jack, Female	C3	30300-3
J106	Connector, Battery	H4	BH-29
Q101	Transistor, NPN, Silicon, 2N3904	B2	TG-47
Q102	Transistor, NPN, Silicon, 2N3904	B2	TG-47
R101	Thick Film Resistor Network	Sev	TF-120
R102	Pot, 200kΩ	A3	RP-97-200k
R103	Pot, 2kΩ	D2	RP-97-2k
R104	Pot, 1kΩ	B4	RP-97-1k
R105	Pot, 500Ω	C2	RP-97-500
R106	Resistor, 180kΩ, 5%, 1/4W, Comp	G3	R-76-180k
R107	Resistor, 47kΩ, 5%, 1/4W, Comp	D4	R-76-47k
R108	Resistor, 470kΩ, 5%, 1/4W, Comp	E3	R-76-470k
R109	Pot, 2kΩ	A3	RP-104-2k
R110	Thick Film Resistor Network	Sev	TF-132
R111	Resistor, 10kΩ, 10%, 2W, Comp	B1	R-3-10k
R112	Resistor, 10M, 10%, 1/4W, Comp	B1	R-76-10M
R113	Resistor, 5.1kΩ, 5%, 1/4W, Comp	E1	R-76-5.1k
R114	Resistor, 1MΩ, 5%, 1/4W, Comp	E1	R-76-1M
R115	Resistor, Selected, 1%, 1/8W, MtF.	B2	R-88-*
R116	Resistor, Selected, 1%, 1/8W, MtF.	B2	R-88-*
R117	Thick Film Resistor Network	Sev	TF-122
R118	Resistor, 150kΩ, 5%, 1/4W, Comp	C5	R-76-150k
R119	Thick Film Resistor Network	Sev	TF-121
R120	Resistor, 10kΩ, 5%, 1/4W, Comp	C2	R-76-10k
R121	Resistor, 10kΩ, 5%, 1/4W, Comp	C2	R-76-10k
R122	Resistor, Selected, 5%, 1/4W, Comp	A3	R-76-*

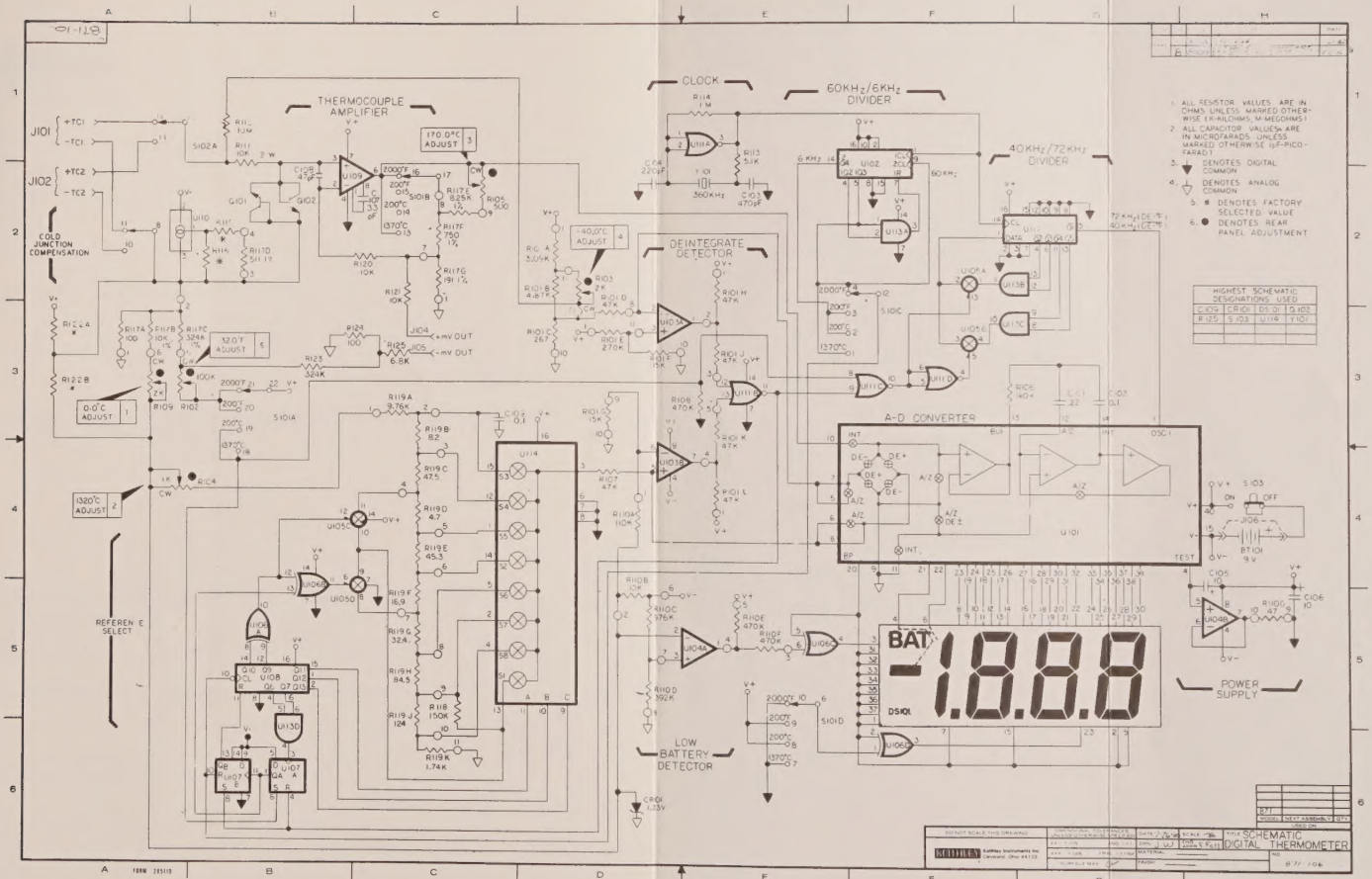
PARTS LIST (CONT.)

Circuit Desig.	Description	Schematic Location	Keithley Part No.
R122	Resistor, 324k, ±0.5%, 1/4W, Mtf	B3	R-88-324k
R124	Resistor, 100Ω, ±0.1%, 1/4W, Comp	B3	R-88-100
R125	Resistor, 6.8k, ±5%, 1/4W, Carbon Film		R-76-6.8k
S101	Switch, Rotary	Sev	SW-428
S102	Switch, Rotary	B1	SW-438
S103	Switch, SPDT, ON-OFF	H4	SW-417
TC-1,2	TC Cable	A1,A2	SC-87
U101	3½ Digit Single Chip A/D Converter	G4	LSI-22
U102	Dual Synchronous Up Counter	F1	IC-282
U103	Low Power JFET Input Op Amp	D3,D4	IC-279
U104	Low Power JFET Input Op-Amp	E5,H5	IC-279
U105	COS/MOS Quad Bilateral Switch	Sev	IC-149
U106	CMOS Quad Exclusive OR Gate	Sev	IC-226
U107	Dual "D" Type Flip-Flop	B6	IC-103
U108	14-Stage Binary Counter	B5	IC-280
U109	Linear Op Amp	B2	IC-203
U110	Current Source	A2	IC-278
U111	Quad 2-Input NOR Gate	Sev	IC-108
U112	COS/MOS Divide by N Counter	G2	IC-145
U113	Quad, 2-Input, AND GATE	Sev	IC-138
U114	Analog Multiplexer	D4	IC-277
Y101	Resonator, 360kHz	E2	CR-14

COMPONENT LAYOUT



SCHEMATIC
MODEL 871 DIGITAL THERMOMETER



KEITHLEY

SERVICE FORM

Model No. _____ **Serial No.** _____ **P.O. No.** _____ **Date** _____

Name _____ **Phone** _____

Company _____

Address _____

City _____ **State** _____ **Zip** _____

List all control settings and describe problem. _____

_____

_____

_____ (Attach additional sheets as necessary.)

Show a block diagram of your measurement system including all instruments connected (whether power is turned on or not). Also describe signal source.

Where is the measurement being performed? (factory, controlled laboratory, out-of-doors, etc.) _____

What power line voltage is used? _____ Variation? _____

Frequency? _____ Ambient Temperature? _____ °F.

Variation? _____ °F. Rel. Humidity? _____ Other? _____

Any additional information. (If special modifications have been made by the user, please describe below.)

_____

_____

*Be sure to include your name and phone number on this service form.

KEITHLEY

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